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OMNITECH STEEL WORKS LTD.

Air Trek 140 - 1985 Trials

Prepared for
Transportation Development Centre
Transport Canada
Montreal

March 1985

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Air Trek 140 - 1985 Trials

Tests on the Air Trek type 140 Hovercraft

Carried out at Quatsino Sound

British Columbia

Prepared for
Transportation Development Centre
Transport Canada
Montreal

By
D.Jones P.Eng.
March 1985

(Ce rapport contient un sommaire en français)

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17. Abstract

This report describes modifications carried out on the Air Trek 140 hovercraft to improve performance and reduce noise. The modifications included installation of a new propeller specially designed for the thrust duct and repositioning of the engine radiator. In addition, sound-proofing material was added to decrease noise in the cabin.

Trials indicated an increase in thrust as a result of the new propeller arrangement, with an overall reduction in noise. Some problems were experienced owing to improper trimming of the rear skirt. These were resolved temporarily by the addition of an apron to the rear skirt segments.

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17. Resumé

Ce rapport décrit les modifications apportées à l'aéroglisseur Air Trek 140 dans le but d'améliorer ses performances et d'en réduire le bruit. Les modifications comprennent l'installation d'une nouvelle hélice spécialement conçue pour le carénage du système propulsif et la relocalisation du radiateur du moteur. De plus, du matériel d'assourdissement a été ajouté afin de diminuer le bruit dans la cabine.

Les essais ont démontré une augmentation de la poussée suite à l'installation de la nouvelle hélice et une réduction générale du bruit. Des problèmes de traînée ont surgit dus à un ajustement incorrect des segments de jupe à l'arrière. Ces problèmes ont été résolus temporairement par l'addition d'un tablier à l'avant des segments en question.

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Summary

The Air Trek 140 is a 16-passenger hovercraft using a single diesel engine to power both the lift and propulsion systems. Although the craft had been certified, and had operated in commercial service, there were areas in which improvements could be made, especially in the reduction of noise and the increase in speed.

The criteria adopted in the design was to use "off the shelf" equipment whereever possible. The previous development program had indicated that a propeller, especially designed to be installed in a thrust duct, would increase the thrust and reduce the noise. Such a propeller was designed and the results supported the prior assessment. Opportunity was taken at that time to re-position the engine radiator to streamline the air flow into the duct.

Additional noise inside the craft was generated by the hydraulic motor of the lift system. The gear ratio was changed to reduce the motor speed, but did not improve the comfort level. Some reduction in noise was obtained by adding more sound proofing material.

The original rear segments had proven satisfactory in previous trials, but they could not be trimmed along with the other skirts when wear occured. An apron was therefore placed across the rear as an interim measure.

The drag from this configuration appeared to be slightly higher and offset the increase in thrust. More design work is needed in this area.

SOMMAIRE

L'aéroglisseur Air Trek 140 est un engin 16 passagers équipé d'un seul moteur diesel pour la sustentation et la propulsion. Bien qu'un certificat de navigabilité ait été décerné et l'appareil mis en service payant, il n'en a pas moins nécessité des travaux visant à réduire les niveaux sonores et à améliorer la vitesse de service.

Au départ, il avait été prévu que l'engin serait équipé d'organes standard; mais, par la suite, il s'est avéré necessaire d'étudier une hélice spéciale devant être montée à l'intérieur d'un carénage afin d'augmenter la poussée tout en réduisant le bruit. Les résultats ont confirmé ces calculs, d'autant plus qu'il avait également été décidé de modifier l'orientation du radiateur de manière à obtenir un meilleur écoulement de l'air dans ce carénage.

En revanche, le moteur hydraulique de sustentation ajoutait aux niveaux sonores. On a tenté de les abaisser en modifiant le rapport d'engrenage du réducteur pour réduire la vitesse de rotation, mais les résultats ont été médiocres. Une certaine atténuation a pu être obtenue par une meilleure isolation acoustique.

Par ailleurs, il a été constaté que les segments arrière d'origine, dont la tenue durant les essais avait été jugée satisfaisante, ne pouvaient pas être coupés pour faire disparaître les traces d'usure, à l'instar des autres segments. Comme mesure correctrice provisoire, un tablier a dû être placé devant eux.

L'effet de cette initiative a été, semble-t-il, d'augmenter légèrement la traînée, annulant l'accroissement de la poussée. La réétude de cette partie s'impose donc.

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1.0 Introduction

This Contract was awarded to improve the performance of the Air Trek Systems Ltd., hovercraft type 140, with particular reference to the drag, thrust and noise.

The program was carried out on Quatsino Sound in the North of Vancouver Island, using the old seaplane ramp at Coal Harbour as the base of operations. The depth sounding was between 50 - 100 metres, thus eliminating any effect from shallow water.

The results will be presented under the task numbers quoted in the Contract.

2.0 Modifications to the Craft

The design of the 140 had been based on the use of "Off the Shelf" equipment, and the original six bladed propeller was selected knowing that it had not been specifically made to run in a duct, suggesting that there may be room for improvement. Since this was the aim of the Contract, a sub contract was let to Dyke and Associates of Florida to provide the optimum propeller design.

Operating experience had also shown that it would be advantagious to carry a spare unit on board. Since the original propeller was not easily stowed, Dyke and Associates were also instructed to split the new propeller into two, two bladed units that could be bolted together at right angles to form a single four bladed unit. The details of the design are presented in paragraph 4.0.

Power is transmitted from the engine to the propeller through a lower sprocket attached to the engine flywheel, and a torque tube located between two bearings. In the original design the top sprocket was located on the front of this tube, and the propeller on the other end. The thrust was introduced into the craft through the large front bearing, which meant that the torque tube also took the compressive loads from the propeller.

There had been several instances of cracks appearing in the end flanges of the torque tube, and since this item must be redesigned for the new propeller installation, the opportunity was taken to revise the complete assembly and take the thrust out in the thrust duct.

The top sprocket and propeller are now on separate stub shafts. The connecting tube transmits torque alone and is protected from engine and propeller vibrations by flexible couplings at each end.

Figs 1 & 2 show the details of the new installations, and the propeller co-ordinates are presented in Appendix "D"

3.0 Task 5.2 A review of the skirt design

The design of the lift system of type 140 differs from other craft insofar as the skirt consists of a number of individual segments, and the fans are located very close to the bow. This position was chosen to reduce the effect of wave pumping in rough water, and also create a high pressure air bubble under the bow to delay the onset of plow-in.

The segments are of the H.D.L. "knee" design, and can be changed in a matter of minutes without the need to jack up the craft. This feature has been of considerable advantage, especially when operating in remote areas or over soft ground. It permits spare segments to be carried on board such that skirt maintainance can be conducted at any convenient time or place.

Any modifications resulting from this review must include this basic concept.

The original design involved placing closed loop segments around the rear corners and across the stern. A small flap extended downwards from the hem and streamed back as the craft moved forward, shutting off the cone and preventing scooping. This configuration was adopted because it had been used successfully on small experimental vehicles built by the National Research Council.

A previous series of tests, carried out over the shallow waters of Mitchell's Bay in Southern Ontario, had indicated high drags, to the point where the vehicle would not accelerate through the hump. The behavior was not always repeatable, which suggested an unpredictable change in the skirt geometry that resulted in scooping.

The problem was examined by Jones, Kirwan & Associates Ltd. on a 1/5th scale model in the towing tank at the National Water Research Institute at Burlington, Ontario, under a contract with the Transportation Development Centre.

The results were presented in report TP 5934 E and showed that the edges of the flaps sometimes curled back into the segments, causing scooping.

One solution would be to duct the fan delivery air directly to the rear segments and inflate them above the cushion pressure. It would provide stiffness to the cones and stop them collapsing. However, this modification would only be considered as a last resort because of the difficulty in installing the required ducting in the vehicle, coupled with the fact that it would probably negate the quick change feature.

The tank tests suggested two other modifications. The first involved placing an apron in front of the rear segments such that it would stream under, and well behind, the skirt. The second was to attach the sides of the flaps to the side walls of the segment, thereby forming a reverse scoop that would avoid water entrainment, and enable obstacles to pass through the rear skirt without snagging.

As an interim measure the edges of all the flaps were joined together to form one single sheet, to represent a short apron. The craft now had no difficulty in accelerating through hump, and all the Certification Trials were carried out with this configuration.

Before entering commercial service the flaps were removed and replaced with reverse scoops attached to the bottom of each of the rear segments.

The design review has been completed.

4.0 Task 5.3 Performance Trials

Before starting these trials the segments were trimmed by cutting off the frayed ends and bringing them all to the correct length, with the craft on cushion. Unfortunately, no provision had been made to adjust the height of the rear segments without removing, and then re attaching, the reverse scoops. Problems had been encountered in gluing in the field due to the pollution on the surface of the material picked from the water. Degreasing was only partially successful and the scoops started to peel off after a few hours, even when reinforced with rivets..

A test was carried out with the scoops unchanged, and protruding into the water some 5 cm more that the remainder. The result was an unacceptable 6 km/h drop in forward speed.

The trials therefore took place with the scoops removed and a temporary apron installed, until an ajustable segment could be designed for the rear.

This had the hidden advantage of improving the logistics by reducing the number of types of segments from four to two, since the front segments could now be used on the rear. Furthermore, there is now no cone in which ice balls can accumulate.

The apron was manufactured from 16 oz skirt material and protected both the corner and stern segments. Several runs were made over a log boom and a highly abrasive shell fish bed without any noticable damage. However, the design lends itself to the use of an abrasive resistant material, such as "Uscothane" should wear become a problem.

The installation was now deemed to be suitable for the tests.

4.1 Instrumentation

The engine and lift system information was taken directly from the craft instrumentation panel. The forward speed was read from the continuous display on the LORAN unit.

Wind and wave conditions were obtained from the local meteorological station.

4.2 Preliminary Test Results

All the basic test data is presented for the 28 points taken in Appendix "A".

The first run was carried out with the craft weight and C.G. position similar to that used at Mitchell's Bay, and therefore the same speed was expected. However, considerable difficulty was experienced in going through the hump and a speed of only 34 km/h was reached, as compared to the previous recording of 50 km/h. Moving the ballast rearward to change the C.G. from +0.4% to -1.2% increased the speed to 57 km/h. The additional 7.0 km/h must be due to the new propeller.

The weight was increased by 520 kg and the speed was again reduced to 33 km/h, regardless of the C.G. position.

Clearly there had been an increase in drag, or a decrease in thrust due to propeller stalling. The possibility of a drag increase was examined first and a window was installed in one of the rear segments so that the motion of the water in the vicinity of the apron could be determined as the craft moved forward.

A wave was seen to be set up in front of the apron, which then rolled over the top and flooded the rear segments at a rate that would not allow the water to drain away. This induced a high drag which resulted in the low speed. It was overcome by raising the top of the apron.

4.3 Pinned Segments

Reference to visual observations and the performance of the segments on video tape, indicated that they were twisting about their attachment points, causing an uneven hem line and a possible increase in drag. This problem had not been noticed in the tank and may have been masked by the stiffness of the model skirt material.

Tabs were glued onto each segment at the "knee" so that they could be joined together to simulate a loop segment configuration The segments were disconnected by removing one plastic bolt which did not increase the time for a segment change.

Run 4 did not show any great improvement in performance, although it was faster than run 1 with the C.G. in the same position. The vehicle was beached and the skirts re-trimmed.

4.4 Performance of the Modified Craft

The majority of the previous data had been obtained at the maximum attainable engine speed. Lower values will now be considered since the performance in the cruise range will be of interest to operators and will enable the drag polar to be constructed.

This series started with run 5 in which plow-in was encountered before the speed was stabilized. The C.G. was progressively moved back until at -1.4% the tendency to plow-in disappeared, although difficulty was experienced in accelerating through hump, suggesting it was close to the aft limit for the weight.

Run 7 shows the effect of engine speed, and hence thrust, on the forward speed, keeping the lift power constant, as indicated by the hydrostat drive pressure.

The same setting was selected for run 8 so that the effect of a wave could be determined. Unfortunately, the cushion air flow had to be increased to avoid plow-in, which masked the results. However, it can be seen that the forward speed is faster than run 7, which suggests that lifting the skirts further out of the water has a greater effect than impact from small waves. The comfort level was acceptable.

Data from run 9 was neglected because the glue line on the apron had failed, exposing the open front of the segment and causing some scooping.

Run 10 was the first test to record head wind and confirmed the theoretical analysis which indicated that the effect of wind alone would be to change the vehicle speed by half the wind velocity. The combination of head wind and waves caused a very hard ride. Removal of every fifth "knee" pin split the skirt up into a number of strips and brought the comfort back to an acceptable level. This configuration was adopted for the remainder of the program.

The same ambient conditions prevailed for run 11, but the C.G. was much further forward. Plow-in was encountered.

It should be noted that plow-in on the 140 is well defined by a gradual reduction in the height at the nose, and can also be identified by the metal ends of the segments tapping on the underside of the hull. Corrective action was always taken at that point and a full plow-in was never permitted to develop.

The theoretical effect of a head wind was again demonstrated in run 12.

The effect of thrust can be derived from run 13, and supports the data from run 7.

Run 14 repeated run 13, but at a weight closer to the Certification limit. Although the C.G. position remained the same there was no evidence of plow-in, probable due to the increased weight and head wind. The test was repeated in run 15, there was no increase in speed over the now calm water, although the tendency to plow-in had re appeared.

Run 16 to 27 were essentially repeats of the previous tests to obtain more data points for the drag polar.

Run 28 was carried out with an over weight craft to gather data which could eventually be used to increase the limits of the Flight Permit. A very low cushion air flow was selected, which allowed for the maximum thrust to be achieved. The forward speed was very close to that for the lighter weight results.

3.5 Performance at Cruise

The engine and forward speeds, together with the manufacturers advertised fuel comsumption, have been used to determine the litre per kilometre required to provide thrust alone. That used by the lift system and the auxiliaries will only raise the general level, but will not affect the slope of the curve.

The results are presented in Fig 1 and show the optimum engine speed to be 2500 rpm, although there is little change over a wide speed range, suggesting that selecting a particular power setting is not critical to the cruise performance.

The test data for the cruise engine speed has been analysed for three weight groups and is presented in Appendix "B". The forward speed has been corrected by a factor equal to half the wind velocity, to reduce the results to a zero wind condition.

The average speed for the three weights are very similar, indicating that weight will not be a major factor in the vehicle economics. The same conclusion applies to the C.G. position.

4.6 Plow-In

There have never been any instances where a complete plow-in has been permitted to develop by the operater. The remedial procedure is to select the maximum lift power, and if this is insufficient, temporarly select reverse thrust. This has little instantanious effect on the forward speed, but will bring the nose back to the level position.

Appendix "A" shows that there have been seven instances of the start of plow-in. However, there does not seem to be any relationship between this event and the speed or C.G. position, apart from the general tendency towards plow-in as the craft speed increases and the C.G. moves forward. Test 23 seems to dispute this conclusion, since plow-in started with a very aft C.G. location.

Since the onset of plow-in is easily identifiable, it does not pose a safety hazard.

4.7 Optimum Lift System Power Setting

The hydraulic motor rpm indicator was not functional during these trials, the fan speed and air flow were obtained from the hydraulic pressure and a calibration curve.

It is logical to assume that as the cushion air flow is reduced, more of the skirt will come into contact with the water and the vehicle speed will drop. The results from Appendix"B" are plotted in Fig 2, and although there is considerable scatter, show the expected trend. Extrapolating the data to the design fan flow of 28 m^3/s would increase the speed by 5.0 km/h. Unfortunately, reducing the power into the propeller by the same amount as that required by the increased fan flow, would drop the craft speed by an even greater amount, resulting in a net loss of speed.

The power absorbed by the lift system does have a significant effect on the fuel flow, and since this is one of the prime items in the operating costs, it follows that the flow should be kept to the minimum, consistant with safety. Under normal operating conditiond this can be as low as 18 m^3/s, although experience has shown that much higher values are needed in rough water and when ice breaking.

4.8 Drag Polar

The thrust versus forward speed is plotted for various rpm's in Fig 3, along with the drag estimated from previous tests. The data from Appendix "B" can now be included and the new drag curve drawn for the three weights.

It can be seen that there is a considerable scatter but a mean line can be drawn through the points. The values are slightly higher than those from Mitchell's Bay, which is suprising, since there is no longer a shallow water effect.

The data does show that if the maximum engine speed of 2800 rpm colud be reached when the craft was on cushion, then the advertised speed of 61 km/h could be achieved.

4.9 "wetted" Drag Coefficient

The results were further analysed by assuming that the drag derived from the estimated propeller thrust, minus the theoretical wave, momentum and aerodynamic drags, would equal the "wetted" drag.

To reduce the data to a non dimensional form the drag must be divided by the water density, the velocity squared and an area. The problem is to determine where the drag acts, so that the correct area can be chosen. Since the results are being compared for the same vehicle, the drag was only divided by the velocity squared, which would bring all the results to a common basis so that the effect of the other parameters could be obtained. It would also enable the performance at different conditions to be predicted.

The data was split into four groups to identify the effect of wind and wave. The results are presented in Appendix "C" and show a considerable scatter in all categories

Examining the calm water conditions indicates that the chosen coefficient can vary between 0.04 to 0.15, and the variations do not seem to be related to the craft weight or C.G. position. However, the values for points taken during a particular run are very similar, suggesting that the measurements are consistant, and the change in value between tests are due to unaccountable differences in drag. Since all the other parameters are constant, it must be due to skirt drag, probably in the apron.

The average value for calm conditions is 0.08, which is twice that previously recorded at Mitchell's Bay. The only difference in the skirt installation is the length of the apron.

The data for wind and waves below 0.5 m is slightly below that for the calm condition, but because of the small number of samples it will be assumed to be the same.

The values for rough water and high wind show a very wide scatter, and may be influenced by the wave length, which was not recorded.

5.0 Task 5.5 Thrust Checks

The running gap between the propeller tip and the shroud was an average of 0.5 cm. The ordinates are given in Appendix "D".

The thrust was measured by a calibrated fish scale, with the craft floating on the water to eliminate any effect of cushion discharge. The results, together with those for the original six blade unit, are presented in Fig 4 and show a 50 kg improvement. Whether this comes from the new propeller, the

revised engine cowlings, or the further aft position of the thrust unit cannot be determined.

After the first few runs it became evident that the protective tape would not stop the leading edge erosion on a long term basis. A stainless steel shoe was therefore attached which caused a discontinuity in the leading edge profile. The thrust was remeasured and a loss of 20 kg recorded.

Since the drag polar had already been established the effect of a change in thrust on forward speed could be predicted, therefore there was no need to repeat any test points.

6.0 Task 5.6 Review of the Hydrostat Drive System

The hydrostat drive had performed well mechanically, but had emitted an unacceptably high noise level at the fan speeds required for operation in rough water or over a porous surface. One possible solution was to change the ratio between the hydraulic motor and the fan.

The original installation of a 60 tooth sprocket on the fan shaft and a 34 tooth sprocket on the cross shaft driven by the hydraulic motor, was changed to 56 and 38 teeth respectively, resulting in a lower motor speed for the same fan speed. The previous high pitched whine changed to an equally objectionable power rumble, and difficulty was experienced in reaching the higher fan speeds.

The system was therefore reverted to the original installation.

7.0 Task 5.7 Noise Abatement

The majority of the noise comes from the engine, hydrostat drive, lift fans and the propeller.

Some of the engine noise results from the open ended exhaust stub which feeds the gases directly into the propeller disc wihout any reduction through a silencer, or pointing the exhaust pipe skyward. These modifications were considered but rejected on the grounds of weight and the fact that the back pressure may cause a drop in power.

7.1 Noise Measurement

The noise levels were measured radially around the craft at a distance of 15 metres. The site consisted of a flat concrete pad surrounded by trees, and was very similar to that at Mitchell's Bay, where the previous recordings had been taken by the Canadian Coast Guard.

Caution must be exercised when comparing the results since the previous data was obtained for the five bladed propeller that absorbed much less power than the current unit.

The following three power settings were considered. The first at maximum power, corresponding to the short period required to accelerate through hump, the second at the cruise setting and the third at the lowest power to sustain a cushion and move the craft away from a residential area.

The measurements were taken at the following locations.

Position No.	Location	Position No.	Location
1	front	5	stern
2	left front quarter	6	right rear quarter
3	left side	7	right side
4	left rear quarter	8	right front quarter
9	cockpit	10	cabin

All measurements are in dbA. The previous results are shown in brackets.

Position	1	2	3	4	5	6	7	8	9	10
Maximum engine power				No cushion						
Engine rpm 2800				Fan rpm 0						
	94	106	107	109	98	109	105	106	no data	
	(99)	(109)	(108)	(110)	(108)	(108)	(110)	(109)	(91)	(98)
Cruise engine power				On cushion						
Engine rpm 2500				Fan rpm 1400						
	92	97	99	105	92	96	98	97	no data	
	(92)	(101)	(101)	(102)	(100)	(102)	(102)	(102)	(88)	(96)
Minimum power										
Engine rpm 1800				Fan rpm 1300						
	84	86	88	89	88	89	87	86	83	85

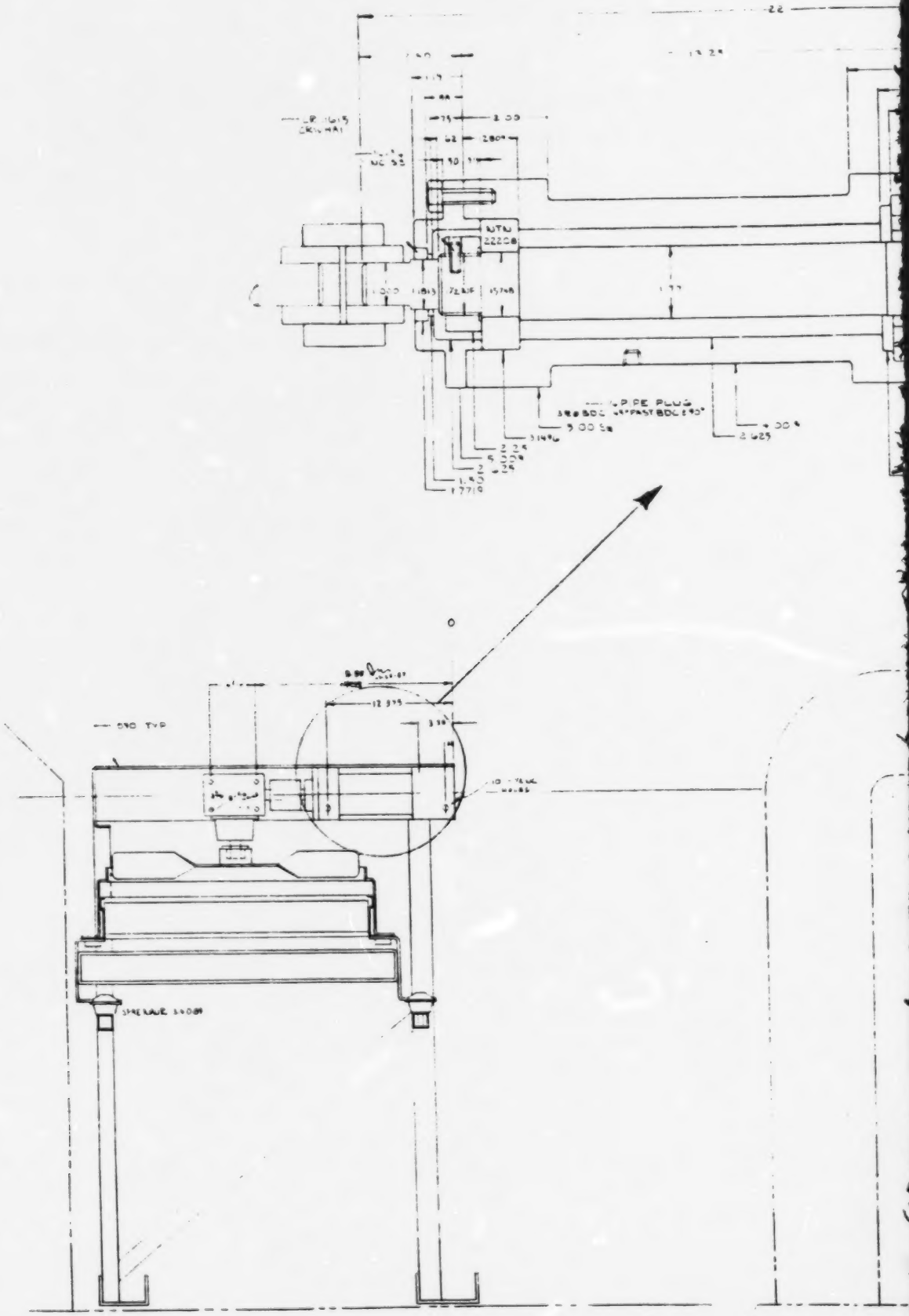
The results at the maximum power setting, off cushion, show an average drop of 3 dbA, which is directly attributable to the new propeller design. These conclusions have been supported by the residents of Coal Harbour.

8.0 Conclusion

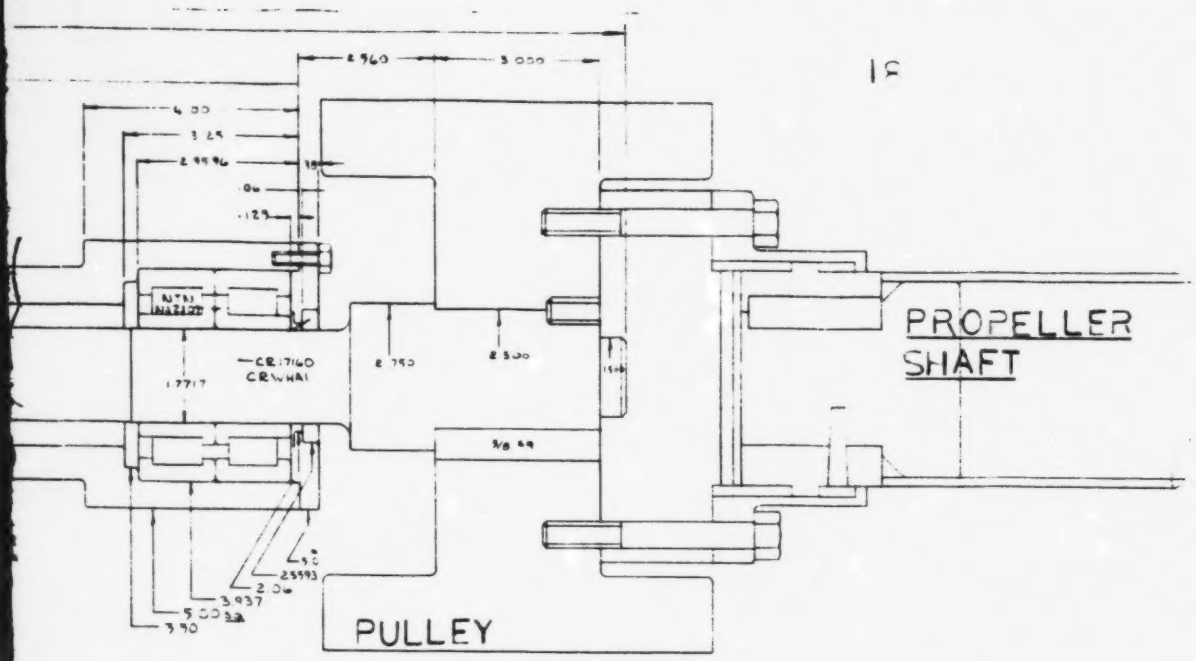
The current development program has improved the commercial acceptability of the 140 through the reduction in noise and the increase in thrust.

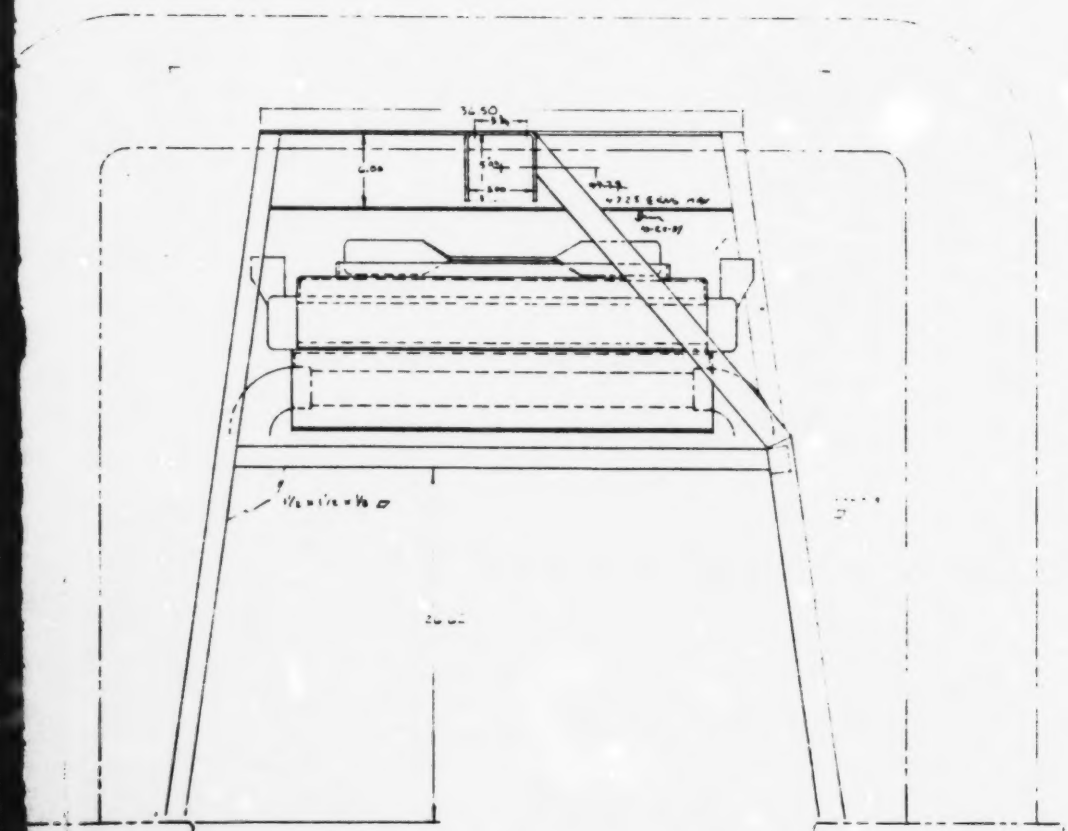
A much clearer understanding of the craft performance has been obtained, particularly the ability to reduce the lift power under most operating conditions. A much lower fuel consumption can now be quoted, which will improve the craft's marketability.

The drag of the apron installation appears to be higher than rear segments with reverse scoops, more design work is required to include the ability to trim the rear skirt with the scoops in place.



NEW RADIATOR ARRAN





ARRANGMENT

FIG 1

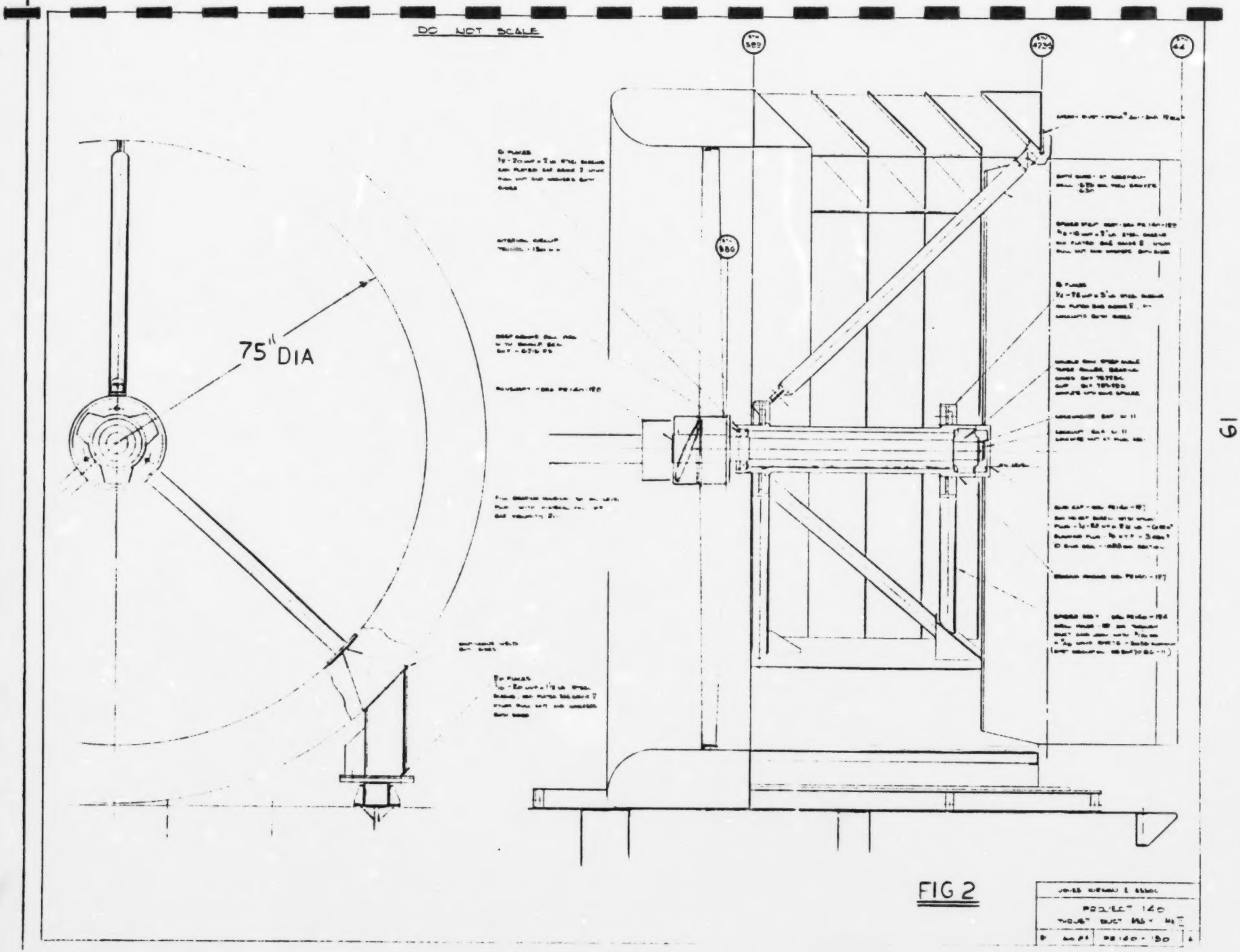


FIG 2

Fuel consumption for the thrust unit

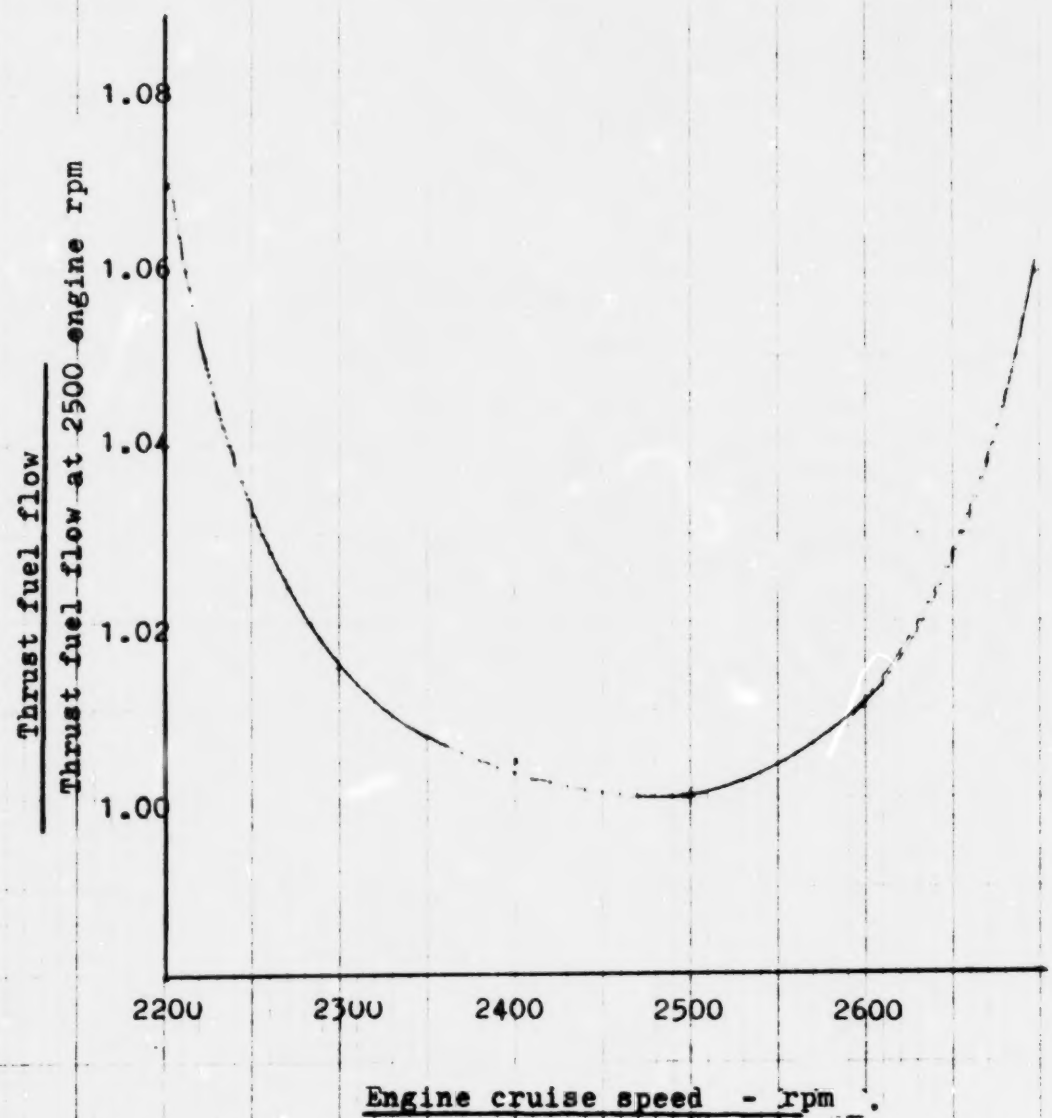


Fig 3

10 Squares to the Inch

Effect of fan flow on forward speed

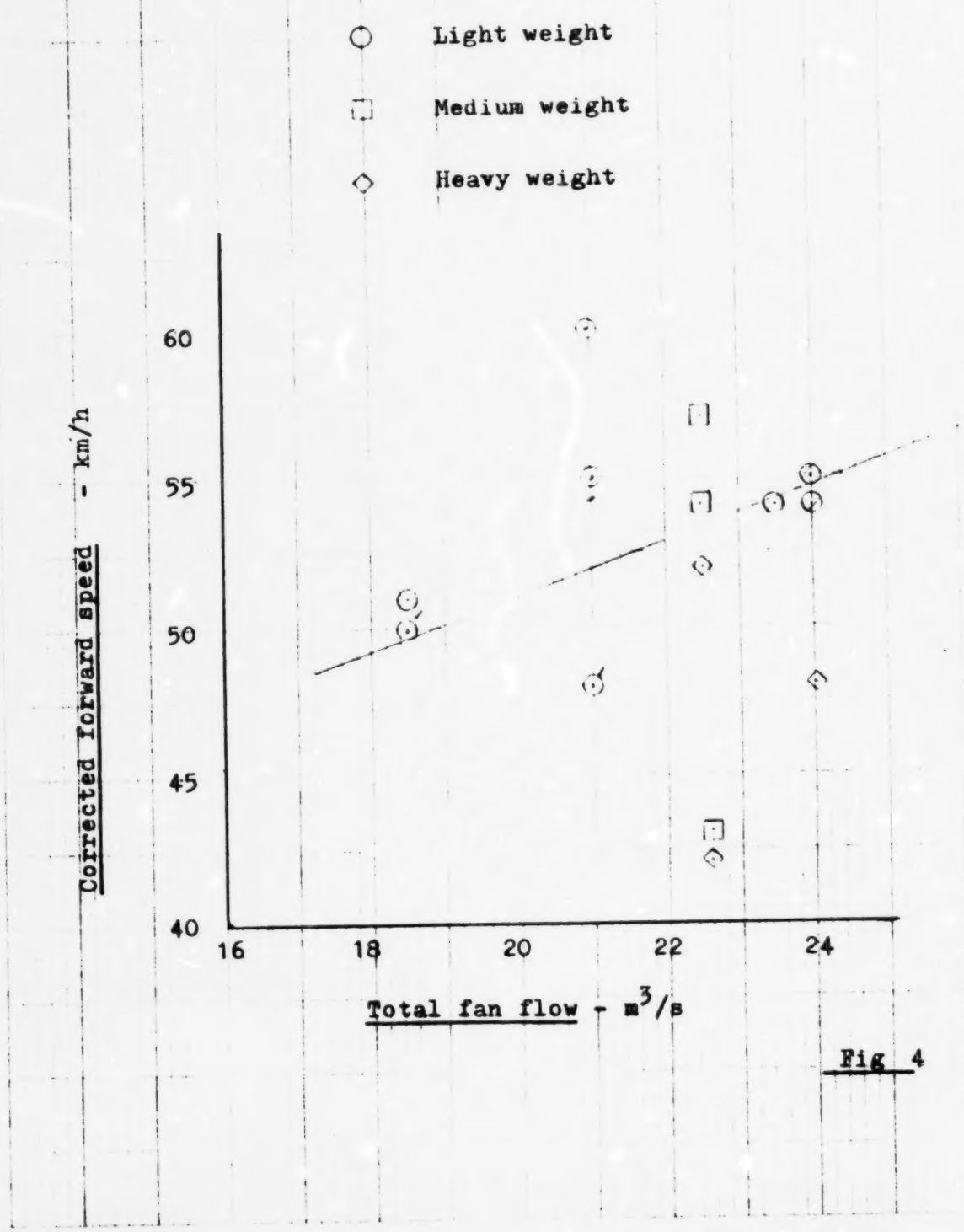


Fig 4

Drag polar

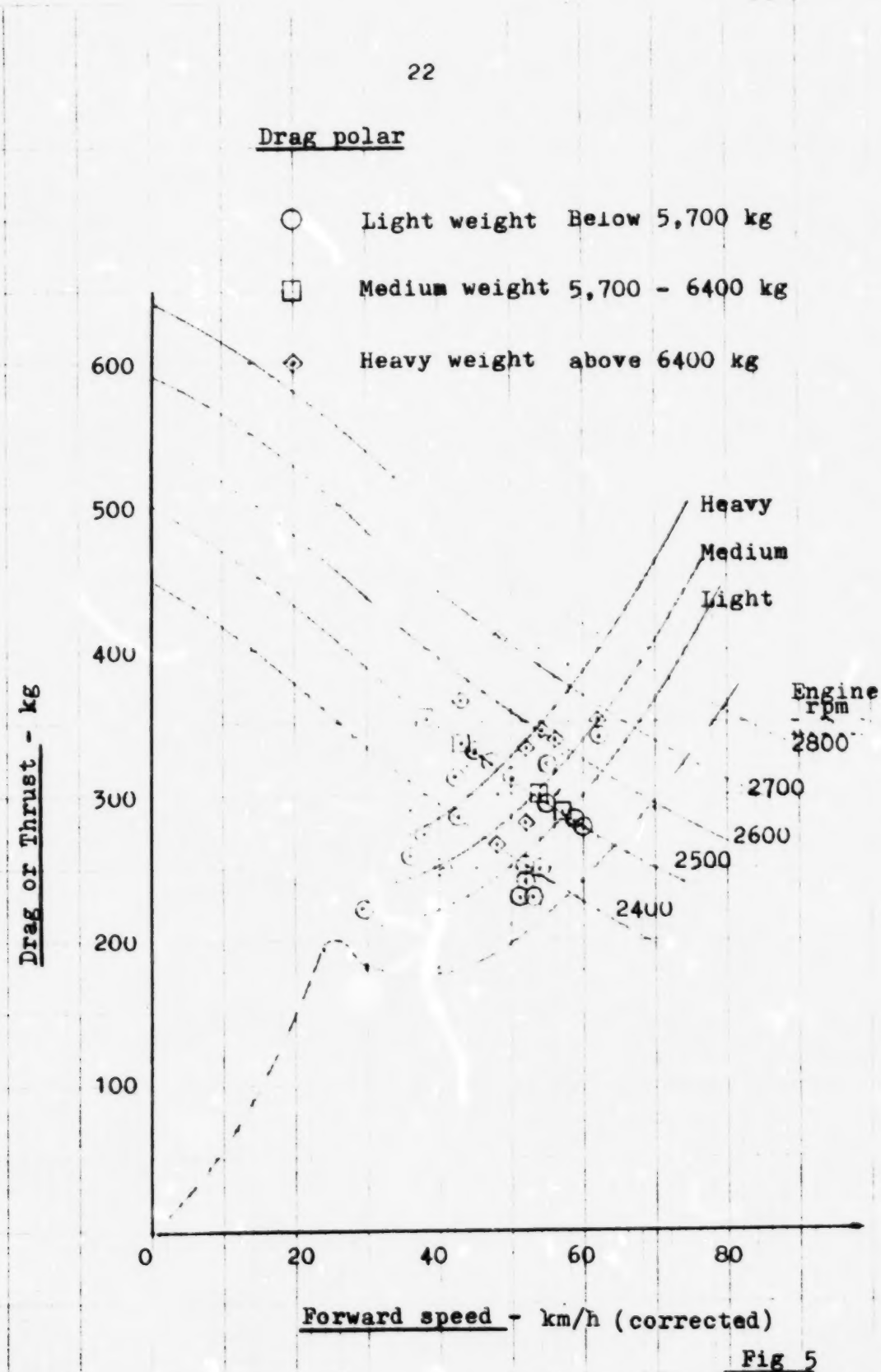


Fig 5

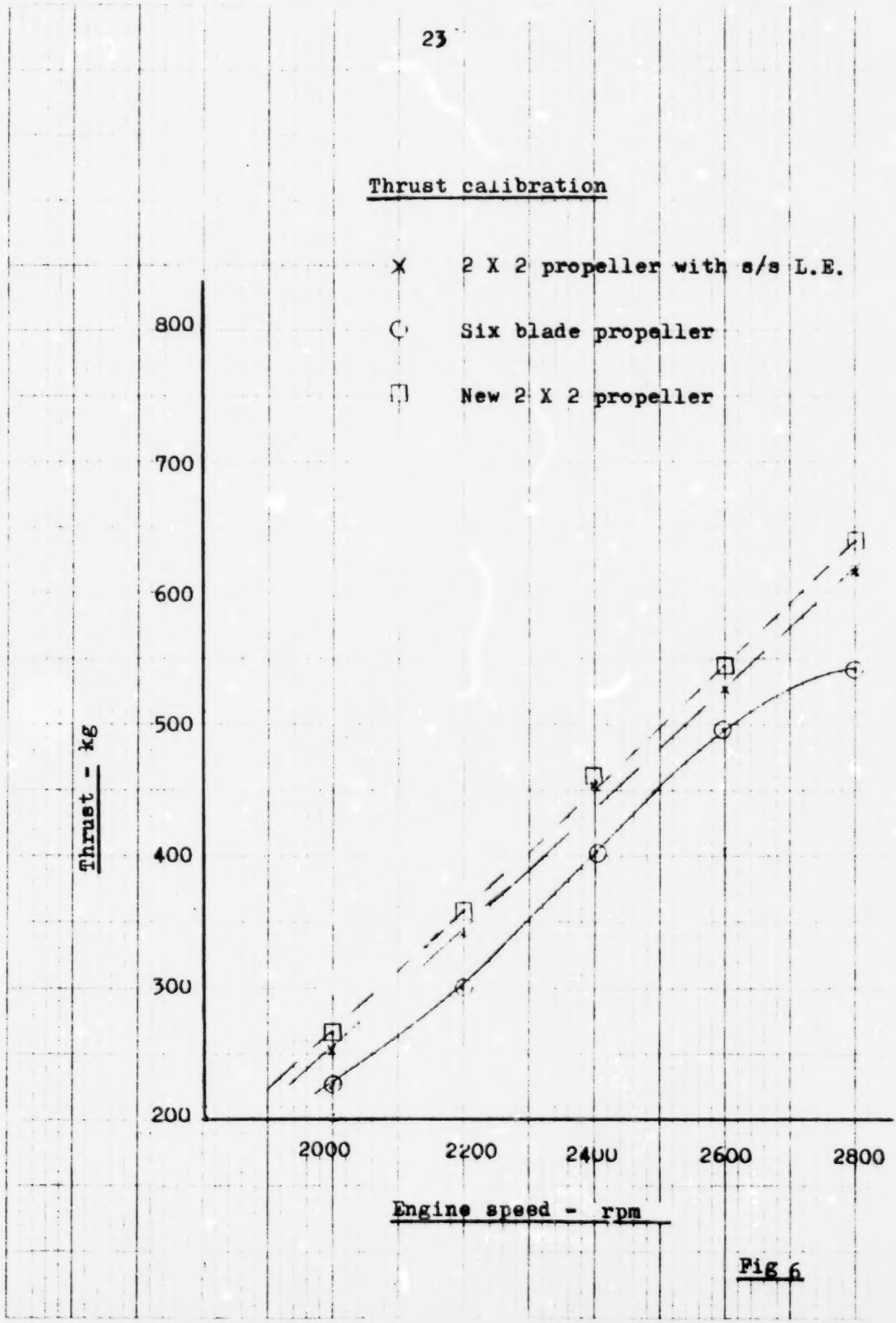

Thrust calibration
2 X 2 propeller with s/s L.E.
Six blade propeller
New 2 X 2 propeller
800
700
600
500
400
300
200
Thrust - kg
2000
2200
2400
2600
2800
Engine speed - rpm

Fig 6

Appendix "A"

Basic Test Data

Run No.	Fwd Speed km/h	Weight kg	C.G %	Engine r.p.m.	Hyd drive Pressure kPa	Wind km/h	Waves m	Remarks
1	34	5530	+0.4	/	/	0	0	Difficulty through hump
2	57	"	-1.2	/	/	0	0	
3	33	6050	-1.0	/	/	0	0	Dificulty through hump
4	45	5520	+0.4	2500	/	0	0	All segments pinned together
5	/	"	-0.8	2500	22,000	0	0	High cushion air flow to stop plow-in
6	55	5590	-1.1	2500	22,000	0	0	No plow-in
7a	38	5570	-1.4	2350	"	0	0	
7b	43	"	"	2400	"	0	0	
7c	55	"	"	2550	"	0	0	
8a	42	"	-1.1	2300	27,600	0	0.3	High cushion air flow to stop plow-in
8b	54	"	"	2400	"	0	0.3	
9	43	6100	-1.0	2500	20,700	0	0.3	Rear apron torn
10a	46	6000	-1.4	2500	"	+17	0.2	Hard ride
10b	57	"	"	"	"	0	0	
11	45	5400	+0.6	2350	24,000	+17	0.2	Reduced speed to stop plow-in
12a	50	5680	-0.1	2500	24,200	+20	0	
12b	40	"	"	"	"	"	"	
13a	55	5400	-0.2	2500	22,000	0	0	Tendency to plow-in
13b	51	"	"	2350	15,800	0	0	
13c	39	"	"	2100	19,300	0	0	

Basic Test Data Continued

Run No.	Fwd Speed km/h	Weight kg	C.G %	Engine r.p.m.	Hyd drive Pressure kPa	Wind km/h	Wave m	Remarks
14a	38	6450	-0.3	2400	26,200	+20	0.1	
14b	42	"	"	2450	20,700	"	"	
14c	44	"	"	2600	24,100	"	"	
15a	42	6620	-0.2	2560	20,700	0	0	Tendency to plow-in
15b	46	"	"	2600	21,400	0	0	
15c	48	"	"	2700	17,900	0	0	
16	48	5500	-0.6	2400	22,080	+7	0.2	
17	50	5900	"	2500	20,600	0	0	Rear apron detached
18	47	5700	-0.8	2500	21,000	0	0	
19	45	5590	"	2300	17,250	-26	0.2	Reduced speed to stop plow-in
20a	36	5580	"	2380	18,600	+35	0.5	Smooth ride in rough water.
20b	38	"	"	2500	17,250	+43	0.6	Every fifth segment loose
20c	40	"	"	2650	19,300	"	"	
20d	60	"	"	2550	"	0	0	
21	41	"	"	2450	"	0	0	
22	38	"	"	2500	"	+25	0.7	

Basic Test Data Continued

Run No.	Fwd Speed km/h	Weight kg	C.G %	Engine r.p.m.	Hyd drive Pressure kPa	Wind km/h	Wave m	Remarks
23a	48	5260	-1.4	2500	19,320	0	0	On the verge of plow-in
23b	67	"	"	2700	20,700	0	0	Fastest speed reached on test
24	58	5660	-0.9	2500	21,400	-8	0	Three rear segments ripped.
25a	41	5510	-1.0	2500	19,300	-33	0.7	Speed reduced due to tail wind
25b	33	"	"	2200	24,100	"	"	" " " " " "
26a	26	5440	-1.1	2500	19,300	+43	0.8	
26b	40	"	"	2550	15,200	+40	0.9	
26c	34	"	"	"	19,300	+38	0.8	
27	43	6700	/	2550	22,100	0	0	Maximum weight permitted.
28	62	7000	/	2650	17,900	0	0	Over weight.

Appendix "B"

Cruise Performance - Engine r.p.m. 2500

Run No.	Weight kg	Measured craft speed km/h	Corrected craft speed km/h	Fan flow m^3/s
Light weight				
13a	5400	55	55	24
7c	5570	54	54	24
24	5660	58	54	23.5
23a	5260	48	48	21
25a	5510	41	26	21
26a	5440	26	48	21
4	5520	45	45	/
6	5590	55	55	21
20d	5580	60	60	21
12a	5680	50	50	18.5
12b	5680	40	50	18.5
22	5580	38	51	18.5
20b	5580	38	60	17
		Average speed	50.5 km/h	
Medium weight				
10a	6000	46	54	22.5
10b	6000	57	57	22.5
9	6100	43	43	22.5
		Average speed	51.3 km/h	
Heavy weight				
14b	6450	42	52	22.5
15a	6620	42	42	22.5
27	6700	48	48	24
		Average speed	47.3 km/h	

Drag Factor

Appendix "C"

Condition		No wind		No waves					
Run No.	Fwd speed km/h	Weight kg	C.G %	K	Run No.	Fwd speed km/h	Weight kg	C.G. %	K
6	55	5590	-1.1	.06	15a	42	6620	-0.2	.12
7a	38	5570	-1.4	.11	b	46	"	"	.12
b	43	"	"	.09	c	48	"	"	.15
c	55	"	"	.07	17	50	5900	-0.6	.08
10b	57	6000	"	.06	18	47	5700	-0.8	.07
13a	55	5400	-0.2	.06	20d	60	5580	"	.05
b	51	"	"	.06	21	41	"	"	.12
c	29	"	"	.04	23a	48	5260	-1.4	.06
27	43	6700	/	.10	b	67	"	"	.04
Average K = .08					28	62	7000	/	.06
Condition		Wind		No waves					
12a	50	5680	-0.1	.08	14a	38	6450	-0.3	.00
Average K = .05					24	58	5660	-0.9	.07
Condition		Wind		Waves below 0.5 m					
8a	42	5570	-1.1	.04	10a	46	6000	-1.4	.03
b	54	"	"	.04	16	48	5500	-0.6	.06
9	43	6100	"	.12	19	45	5590	-0.8	.08
Average K = .06									
Condition		Wind		Waves over 0.5 m					
20a	36	5580	-0.8	.00	25a	41	5510	-1.0	.30
b	38	"	"	.00	b	33	"	"	.50
c	40	"	"	.05	26a	26	5440	-1.1	.00
22	38	"	"	.12	b	40	"	"	.00
Average K = .10					c	34	"	"	.50

Appendix "D"

Propeller Co ordinates RAF section - Chord Line is Flat Undersurface

x/c	Sta. 11.25"		Sta. 16.875"		Sta. 22.5"		Sta. 28.125"		Sta. 33.75"		Sta. 37.5"	
%	x"	y"	x"	y"	x"	y"	x"	y"	x"	y"	x"	y"
1.25	.086	.467	.092	.341	.077	.227	.069	.170	.064	.143	.063	.132
2.5	.171	.646	.183	.472	.153	.315	.137	.236	.128	.198	.125	.132
5.0	.343	.892	.367	.651	.306	.435	.275	.325	.256	.273	.250	.252
7.5	.514	1.059	.550	.773	.459	.516	.412	.386	.384	.324	.375	.299
10.0	.685	1.184	.733	.864	.612	.577	.549	.431	.512	.362	.500	.334
15.0	1.028	1.358	1.100	.991	.918	.662	.824	.495	.768	.415	.750	.383
20.0	1.370	1.448	1.466	1.057	1.224	.706	1.098	.528	1.024	.443	1.000	.408
30.0	2.055	1.507	2.199	1.100	1.836	.734	1.647	.549	1.536	.461	1.500	.425
40.0	2.740	1.495	2.932	1.091	2.448	.729	2.196	.545	2.048	.457	2.000	.422
50.0	3.425	1.434	3.665	1.046	3.060	.699	2.745	.522	2.560	.438	2.500	.404
60.0	4.110	1.314	4.398	.959	3.672	.640	3.294	.479	3.072	.402	3.000	.371
70.0	4.795	1.127	5.131	.822	4.284	.549	3.843	.410	3.584	.344	3.500	.318
80.0	5.480	.865	5.864	.631	4.896	.421	4.392	.315	4.096	.264	4.000	.244
90.0	6.165	.555	6.597	.405	5.508	.270	4.941	.202	4.608	.170	4.500	.156
95.0	6.508	.377	6.964	.275	5.814	.184	5.216	.138	4.864	.115	4.750	.106
100.0	6.850	.111	7.330	.081	6.120	.054	5.490	.041	5.120	.034	5.000	.031
L.E.rad	.359		.179		.096		.060		.045		.039	
T.E.rad	.111		.081		.054		.041		.034		.031	
t/c max	22		15		12		10		9		8.5	
β°	39°51'		25°55'		20°12'		16°42'		14°0'		12°38'	